

Progress Report No. 12

**"A Theoretical and Experimental Study of the Ionosphere
Using Radio Signals from Earth Satellites"**

Grant Number NSG 24-59

from

The National Aeronautics and Space Administration

FACILITY FORM 602	N 66 81460	(THRU)
	5	None
	CR-70074	(CODE)
	(INASA CR OR TMX OR AD NUMBER)	(CATEGORY)

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K. C. Yeh, Co-Investigator

Period Covered: July 1, 1965 to December 31, 1965

January 1, 1966

The Electrical Engineering Research Laboratory

University of Illinois

with the cooperation of the

University of Illinois Observatory

Urbana, Illinois

Introduction

This report describes the continuation of ionospheric research at the Radio Astronomy Laboratory of the University of Illinois. The program began in the early part of 1958, soon after the launching of the first artificial satellite. The principal research areas can be roughly divided into two parts: the experimental and the theoretical. The subjects of the experimental research are the study of scintillation and the study of Faraday rotation of polarization of radio signals from satellites. The scintillation of signals is related to the existence of irregularities of ionization in the ionosphere. The Faraday rotation is a measure of electron content. The theoretical studies are concerned with wave propagation and astronomy. These are intimately related to the experimental program under investigation.

Field Operations

All four field stations (Urbana, Houghton, Baker Lake, and Adak) are in operation during the reported period. The methods of recording were described in the last progress report (Progress Report No. 11).

The Adak station has been operated successfully by the U.S. Army Signal Corp. It was learned that the Army can no longer carry out this function after December 31, 1965. In view of its importance in our study, especially in connection with the conjugate study the station should be maintained. At present, arrangements are being made to have the equipment transferred to the Office of the Chief Naval Operations at Adak so that recordings can be continued.

Data Analysis

The Faraday rotation analysis of 54 mc/s signals from 1961 Omicron recorded at Houghton has been completed. The results are being studied and compared with the Urbana results for the same period.

A new computer program is being written to speed the data analysis using the differential Faraday rotation method. The data analysis of EE-B has just begun.

Scintillation indices on 40 mc/s from EE-B and recorded at Adak have been tabulated for the period November, 1964 to August, 1965. Wellington scintillation indices covering approximately a half-year period have been forwarded by Mawdsley.

OGO-1 records are being studied. Because of satellite spin a number of difficulties in record analysis is introduced. Attempts are being made to extract as much information as possible. This is conducted by Dr. Rao.

Experimental Results

The results on scintillation observations have been submitted to and accepted for publication in the Journal of Atmospheric and Terrestrial Physics.

The results on Faraday rotation observations at Urbana are being prepared. A preliminary account was presented at 1965 Fall URSI. Using diffusion transport layer as a model the electron content can be related to a number of physical processes and parameters, e.g. electron-ion temperature ratio and diffusion coefficient. Similar studies are being carried out for records taken at Houghton to study the latitude effect.

The conjugate correlation of scintillations at Adak and Wellington is still in progress.

Theoretical Studies

The study of wave propagation in a random medium is continued. A report on the study of cross-correlation of signals received at two stations after passing through a slab of irregularities from the transmitting satellite was published. It was found that the maximum correlation occurs when two rays intersect in the slab. The results have been accepted for publication by the Journal of Atmospheric and Terrestrial Physics.

The result of ion-exosphere study has been submitted to the Journal of Geophysical Research for publication. This was carried out with Dr. J. E. C. Gliddon when he was visiting at the University of Illinois and completed after his return to England.

A program on the stability study was initiated during the reported period. It was found that if the electron density height gradient is sufficiently large and positive the ionosphere may be unstable. Some experimental evidence has been found, showing the appearance of irregularities when the gradient steepens. The result has been submitted for publication in the Physics of Fluids.

Conferences

The following papers were presented at conferences.

1. "A Steady State Fluid Model of the Ion-Exosphere," J. E. C. Gliddon and K. C. Yeh, Fifth Western National Meeting of the American Geophysical Union, Dallas, Texas, September, 1965.
2. "Diffraction of Random Waves in An Anisotropic Medium," K. C. Yeh, Tenth AGARD Ionospheric Research Committee Meeting on Propagation Factors in Space Communications, Rome, Italy, September, 1965.
3. "Ionospheric Electron Content at Temperate Latitudes during the Declining Phase of Sunspot Cycle," K. C. Yeh and B. J. Flaherty, 1965 Fall URSI Meeting, Dartmouth College, Hanover, New Hampshire, October, 1965.
4. "Stability Study of the Ionosphere," C. H. Liu and K. C. Yeh, Plasma Physics Conference, San Francisco, November, 1965.

Publications

The following publications have appeared or have been completed during the report period.

1. P. R. Krass and K. C. Yeh, "Scintillation Observations of Satellite Signals," accepted for publication by Journal of Atmospheric and Terrestrial Physics.
2. C. H. Liu, "Cross-Correlation Functions of Spherical Waves Propagating through a Slab Containing Anisotropic Irregularities," EERL Technical Report, August, 1965. Accepted for publication by Journal of Atmospheric and Terrestrial Physics.
3. K. C. Yeh, "Diffraction of Random Waves in a Homogeneous Anisotropic Medium," to appear in Proc. Tenth AGARD Ionospheric Research Committee Meeting.
4. J. E. C. Gliddon and K. C. Yeh, "Steady State Fluid Models of the Ion-Exosphere." Submitted for publication to Journal of Geophysical Research.
5. C. H. Liu and K. C. Yeh, "Low Frequency Waves and Gradient Instabilities in the Ionosphere." Submitted for publication to Physics of Fluids.

Personnel

The following persons were involved in project activities during the report period.

Dr. G. W. Swenson, Jr.	Principal Investigator	Not paid by Project
Dr. K. C. Yeh	Co-Investigator	1/2 time
Dr. N. Narayana Rao	Assistant Professor	1/2 time beginning 9/65.
Dr. C. H. Liu	Research Associate	3/4 time
Dr. James F. Phelan	Research Associate	1/4 time. Resigned 9/65.
Dr. Daniel B. Hodge	Visiting Assistant Professor	1/2 time. Resigned 7/65.
Bernard J. Flaherty	Electronic Engineer	Full time
Anthony Szelpal	Electronic Technician	Full time
Chyang Hsieh	Research Assistant	1/2 time
Dale M. Simonich	Research Assistant	1/2 time
Andrew P. Weise	Research Assistant	1/2 time
Wilbur L. Allain	Research Assistant	1/2 time. Resigned 9/65.
Christian Segers	Research Assistant	1/10 time

Several hourly student assistants have also been employed.